ITR/SY: Center for Modeling of Quantum Dynamics, Relaxation and Decoherence in Solid-State Physics for Information-Technology Applications

PI: Vladimir Privman, Clarkson University, DMR Award 0121146

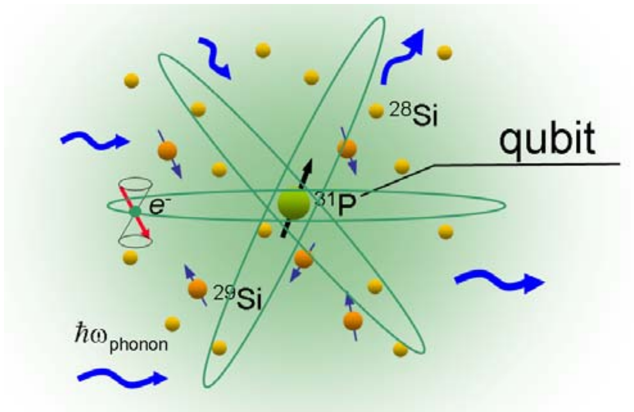
The main **objective** of our program has been to explore *coherent quantum mechanical processes* in novel solid-state semiconductor information processing devices, with components of atomic dimensions. These include quantum computers, spintronic devices, and nanometer-scale logic gates.

Our **achievements** to date include:

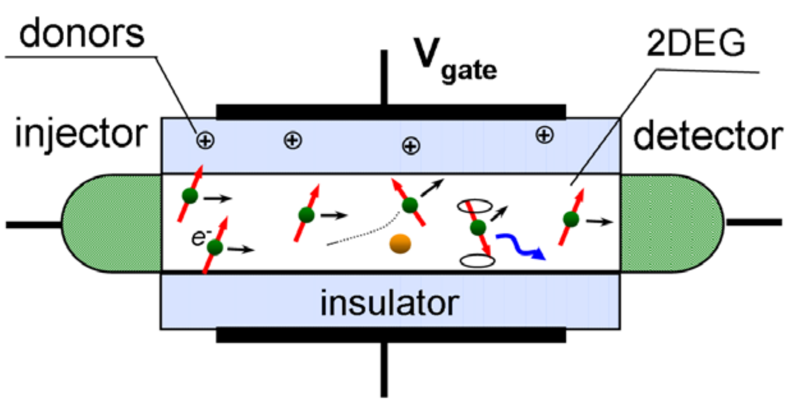
New measures of initial decoherence, and evaluation of decoherence for spins in semiconductors.

Evaluation of solid-state quantum computing designs, and studies of transport associated with quantum measurement.

Investigation of spin-polarized devices and role of nuclear spins in spintronics and quantum computing.



Donor electron spin in silicon decohers owing to interactions with phonons and nuclear spins



Spin-flip scattering in semiconductor nano-device

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Our program has involved four co-PIs: **M.-C. Cheng, M. L. Glasser, D. Mozyrsky, Ch. Tamon**, and extensive collaborations with leading experimental groups and with Los Alamos National Laboratory.

The **educational impact** has included training of 3 undergraduate students, 4 graduate students, 4 postdoctoral researchers, and development of a new course to introduce quantum device concepts to Physics and Electrical & Computer Engineering students.

Our **outreach program** has included sponsoring presentation events, and an international workshop *Quantum Device Technology*, held at Clarkson University in May of 2002.

Our results were published in several papers in refereed journals, and we set up a web site for outreach.

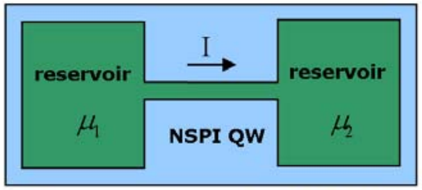
For a spin system in a bosonic bath, we find

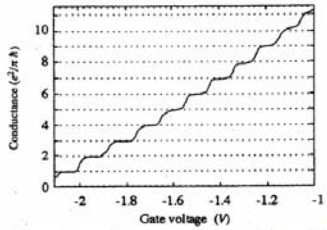
$$\|\delta\| = \left[\left(\rho_{\uparrow\uparrow}(0) - \rho_{\downarrow\downarrow}(0)\right) \frac{\left(1 - e^{-B^2(t)}\right)}{2} \right]^2 + \left[\left(1 - e^{-B^2(t)}\right) \left|\rho_{\uparrow\downarrow}(0)\right| \sin\left(\tfrac{\Omega}{2} t - \varphi_0 \right) \right]^2 =$$

$$= \left(1 - e^{-B^2(t)}\right) \left(\frac{\left(\rho_{\uparrow\uparrow}(0) - \rho_{\downarrow\downarrow}(0)\right)^2}{4} + \left|\rho_{\uparrow\downarrow}(0)\right|^2 \sin^2\left(\tfrac{\Omega}{2} t - \varphi_0 \right) \right)^{1/2}$$

where the norm for the density operator deviation is defined as

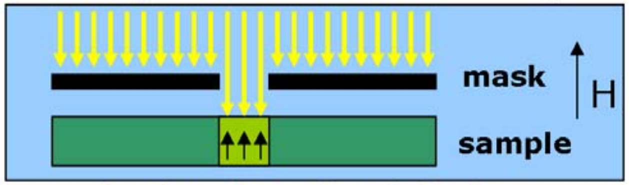
$$\|\delta\| = \sup_{\varphi \neq 0} \frac{\left\| \left(\rho - \rho^{(0)}\right) | \varphi > \right\|}{\left\| \, | \varphi > \right\|}$$





Transport through NSPI QW

Conductance quantization



Local nuclear spin polarization